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FLOOD DAMAGE ASSESSMENTS USING SPATIAL DATA MANAGEMENT TECHNIQU--ETC(U)
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FLOOD DAMAGE ASSESSMENTS USING SPATIAL DATA MANAGEMENT TECHNIQUES

by

DARRYL W. DAVIS

&

R. PAT WEBB

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The Corps of Engineers Hydrologic Engineering Center has developed techniques that perform the spatial data analysis approach and individual structure approach and work is near completion on an integrated analysis package. The capability therefore exists to perform damage appraisals in a manner that encourages a general geographic and land use approach (thus greatly facilitating the study of nonstructural measures) while preserving the ability to analyze individual, unique structures should the need arise.

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FLOOD DAMAGE ASSESSMENTS USING SPATIAL DATA MANAGEMENT TECHNIQUES[1/]

by

Darryl W. Davis [2/] and R. Pat Webb [2/]

INTRODUCTION

Modern damage appraisals serve the joint tasks of estimating existing damage potential and providing the bases for formulation and evaluation of a range of management actions expected to perform under alternative future development patterns and land use management policies. Spatial data management techniques in which land use, topographic and other natural resource information is catalogued into computerized data files offers substantial potential for performing comprehensive flood damage analysis to meet these needs. The strength of the techniques are the geographic and land use orientation that must be adopted to apply the methods and the significant opportunity to quantitatively assess land use development patterns and policies.

In most flood plains, several unique activities that may collectively involve one or more structures do not fall into logically defined land use or damage potential categories. These may be major industries, unique commercial properties, or religious and service groups. Cataloguing and

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managing the damage potential of these structures individually seems appropriate to maintain credibility in the analysis.

The Corps of Engineers Hydrologic Engineering Center has developed techniques that perform the spatial data analysis approach and individual structure approach and work is near completion on an integrated analysis package. The capability therefore exists to perform damage appraisals in a manner that encourages a general geographic and land use approach (thus greatly facilitating the study of nonstructural measures) while preserving the ability to analyze individual, unique structures should the need arise.

This paper discusses the basic concepts of a spatial data management approach to damage appraisals and highlight(s) its integrated use with more traditional individual structure approaches. Selected example results are presented.

FLOOD DAMAGE ASSESSMENT CONCEPTS

Flood damage assessments are performed to provide quantitative information on the social cost of flooding and to provide a sound basis for formulating, evaluating and implementing a range of remedial management actions. Flood damage potential assessments of existing flood plain development provide the basis for identifying critical problem areas and for development of actuarial insurance premiums for government and private industry. Damage appraisals performed in the aftermath of flood events provide the data used as the basis for the efficient and equitable allocation of relief funds and other emergency assistance. Damage estimates of potential future development scenarios can encourage local government agencies and private

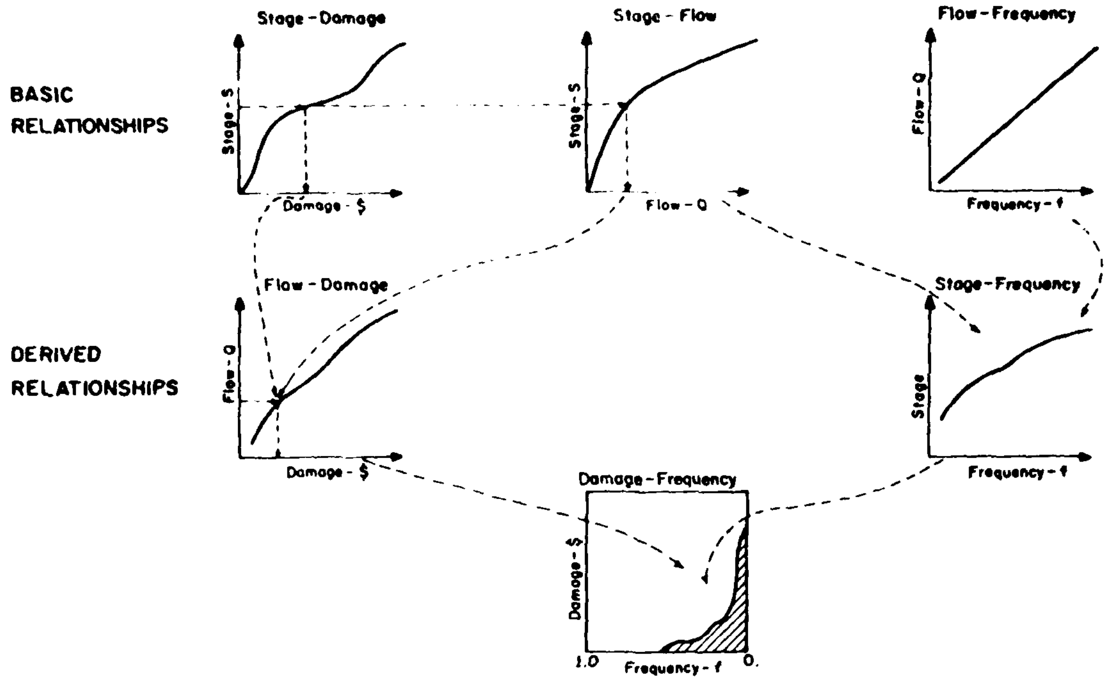
individuals to make wise land use decisions considering the flood hazard consequences. Several types of analysis' for a range of development conditions and careful segmenting of damageable areas' are required to meet these information needs.

The two major types of damage appraisals performed to supply these information needs are 1) "event" analysis (often referred to as single event damage), and 2) expected annual damage analysis (often referred to as average annual damage). The damage assessments for both types involve technical procedures to develop and make coordinated use of economic (damage), hydrologic, and hydraulic data.

The single event analysis includes development of a damage potential function (elevation-damage curve), and hydrologic data (perhaps only stage) for the event of interest. The damage for the event is simply "read out" for the flood level of interest.

The expected annual damage analysis requires the additional development of exceedance frequency information which is used to perform the probability weighting. This could include a stage-exceedance frequency function directly or more commonly, the development of a flow-exceedance frequency function (commonly referred to as a frequency curve) and an elevation-flow curve (commonly referred to as a rating curve).

Figure 1, Damage Computation Concepts (Hydrologic Engineering Center, June, 1977) reproduced here summarizes the functional relationships and their respective role in damage appraisal studies directed toward computing the expected annual damage. The final step in the appraisal is conceptually illustrated by the hatching of the Damage-Frequency relationship. The



The basic functional evaluation relationships and the derived relationships are shown above and how they are constructed is described herein.

Stage-Flow Relationship: This is a basic hydraulic function that expresses, for a specific location, the relationship between flow rate and stage and is frequently referred to as a 'rating curve.' It is usually derived from water surface profile computations.

Stage-Damage Relationship: This is the economic counterpart to the stage-flow function and represents, at a specific location, the damages which will occur in a river reach at various river stages. Usually the damage represents an aggregate of damage which occur some distance upstream and downstream from the specified location. It is usually developed from field damage surveys.

Flow-Frequency Relationship: This defines the relationship between exceedance frequency and of annual peak flow at a location. It is the basic function describing the probability nature of stream flow and is commonly determined from either statistical analysis of gaged flow data or through watershed model calculations.

Damage-Frequency Relationship: This relationship is derived by combining the previously discussed basic relationships using the common parameters stage and flow. For example, the damage for a specific exceedance frequency is determined by ascertaining the corresponding flow rate from the flow-frequency function, the corresponding stage from the stage-flow function and finally the corresponding damage from the stage-damage relationship. Any changes which occur in the stage-damage, stage-flow or flow-frequency function because of watershed, development or flood plain management measure implementation will be reflected in the damage-frequency function and therefore the magnitude of the expected annual damage computed as the integral (area underneath) the function.

Other Functional Relationships: The flow-damage relationship is developed by combining the stage-damage with the stage-flow relationship using stage as the common parameter. The stage-frequency relationship is developed by combining the stage-flow with the flow-frequency relationship using flow as the common parameter. The damage-frequency relationship could then be developed as a further combination of these derived relationships.

Figure 1

DAMAGE COMPUTATION CONCEPTS

expected value is the probability weighted value and is shown as the area under the curve. This is exactly identical to computing the mathematical expectation of a cumulative distribution function. As would be expected, present day analysis is often computerized so that the integration to compute the expected value is performed by numerical methods.

Flood plain areas for which damage appraisals are performed normally encompass rather extensive stream reaches in which there can be significant changes in the basic evaluation functions from one location to another. It is common practice to subdivide the damageable area into "damage reaches" for which a unique set of the functional relationships is developed. Criterion for determining the geographic extent of the reaches includes a) reasonably uniform hydraulic response (parallel water surface profiles for the range of flows which are significant to the calculation of expected annual damages), b) a constant flow regime (no significant flow changes, such as tributaries, encompasses), c) political, economic and other aggregation units of interest preserved and d) allowance for accurate analysis of the range of management actions that might be investigated. As an example, a study area such as the vicinity of Athens, Georgia (200 square miles) might be partitioned into 70 to 80 damage reaches, each of which would have the unique evaluation functions of a damage curve, an exceedance frequency curve, and a rating curve prepared.

The individual functions may be developed by several alternative means. The text in Figure 1 suggests a few. The damage potential function is singled out for discussion and analysis in this paper because it is the primary

mechanism for quantifying the direct effect of flood plain management actions intended to be applied to both existing and future development patterns.

DEVELOPMENT OF DAMAGE POTENTIAL FUNCTIONS

The most direct and complete approach to development of damage functions for present flood plain development would be to perform a complete exhaustive inventory of the structures and terrain in the flood plain. This would include surveying the ground floor elevation of all structures and examination of each structure and its contents to determine the damage potential. Several other approaches from this exhaustive inventory to structure and terrain generalization (the spatial approach) are briefly discussed below.

A less intense inventory approach could be to approach the task as a structure inventory, but to classify and generalize the types of structures and their damage potential. Structures are thus grouped and inventorying proceeds basically to catalogue terrain and structure/contents type. This is a common approach for damage function development for flood plains with a manageable number of structures. A more statistically based approach used increasingly more often in recent years, would be to stratify the flood plain development by damage potential, then sample the stratified categories applying principles of statistical sampling theory. The stratification would probably be by structure type, flood potential, structure value, and terrain. Note that not all structures would be catalogued and analyzed - only those "sampled". After the stratified sample has been analyzed, the damage potential for the entire study area is projected. Further generalization of damage function construction is possible by "zoning" the flood

plain into homogeneous areas of damage potential (say common structure types and common elevation). This latter is a common approach that moves away from individual structures into a more general land use approach.

The spatial data management approach has characteristics of most of the above approaches integrated into its method. Flood plain occupancy is determined by grouping development into land use categories, damage potential is determined by sampling structure types and values within the land use categories to develop composite damage functions, and the terrain variation is preserved by gridding the stream reaches and assigning elevations to the grids. The size of the grid that should be used is a function of the terrain and land use variation. To date most studies use 1.148 acre grids although a range of 0.18 - 4.5 acres has been employed in other studies. The approach has been devised so that all data are locationally accurate (referred to as having spatial integrity) and thus the method is computerized and directly linked to modern geographic analysis concepts. The approach therefore has a significant land use focus and is easily applied to the study of land use management policies and nonstructural flood plain management alternatives. An important concept central to the spatial approach to damage appraisals is the grid cell data bank (the gridded geographic data file).

GRID CELL DATA BANK

A grid cell data bank is a stored computer file of spatial data (map type data) which can be accessed and processed for a variety of analyses. "Guide Manual for the Creation of Grid Cell Data Banks" (Hydrologic Engineering Center, June 1978), contains detailed guidance on the creation of

data banks. The stored data bank is the central feature of damage appraisals using spatial data management techniques.

Spatial data occurs both as discrete forms that can be bounded by definite lines (e.g. land use, damage reaches, etc.) and as continuously changing data (e.g. topographic elevation). Discrete types of data may be classified into groups and legended, while continuous data can be assinged a representative value for each specific grid (e.g. topographic elevation for each grid).

The location of each cell and the value (legend) for each variable must be recorded. This is accomplished by cataloguing each grid cell with a specific location (row and column) as the first two values for a grid cell record. All data associated with a particular grid cell is then stored sequentially at the address specified for that grid cell. The stored data bank exists as a matrix of numbers which identify data values and location.

Part a of Figure 2, Grid Cell Data Bank Concepts, illustrates conceptually how a single data variable may be visualized as a numerical matrix with the three dimensions of row, column and data value for each grid cell. Figure 2b illustrates conceptually a portion of a grid cell data bank containing several data variables. Grid data stored to represent several variables is referred to as a multivariable file.

The specific data variables and their characteristics that must be placed in a gridded data base, together with the procedures for processing to perform damage appraisals are discussed in subsequent paragraphs.

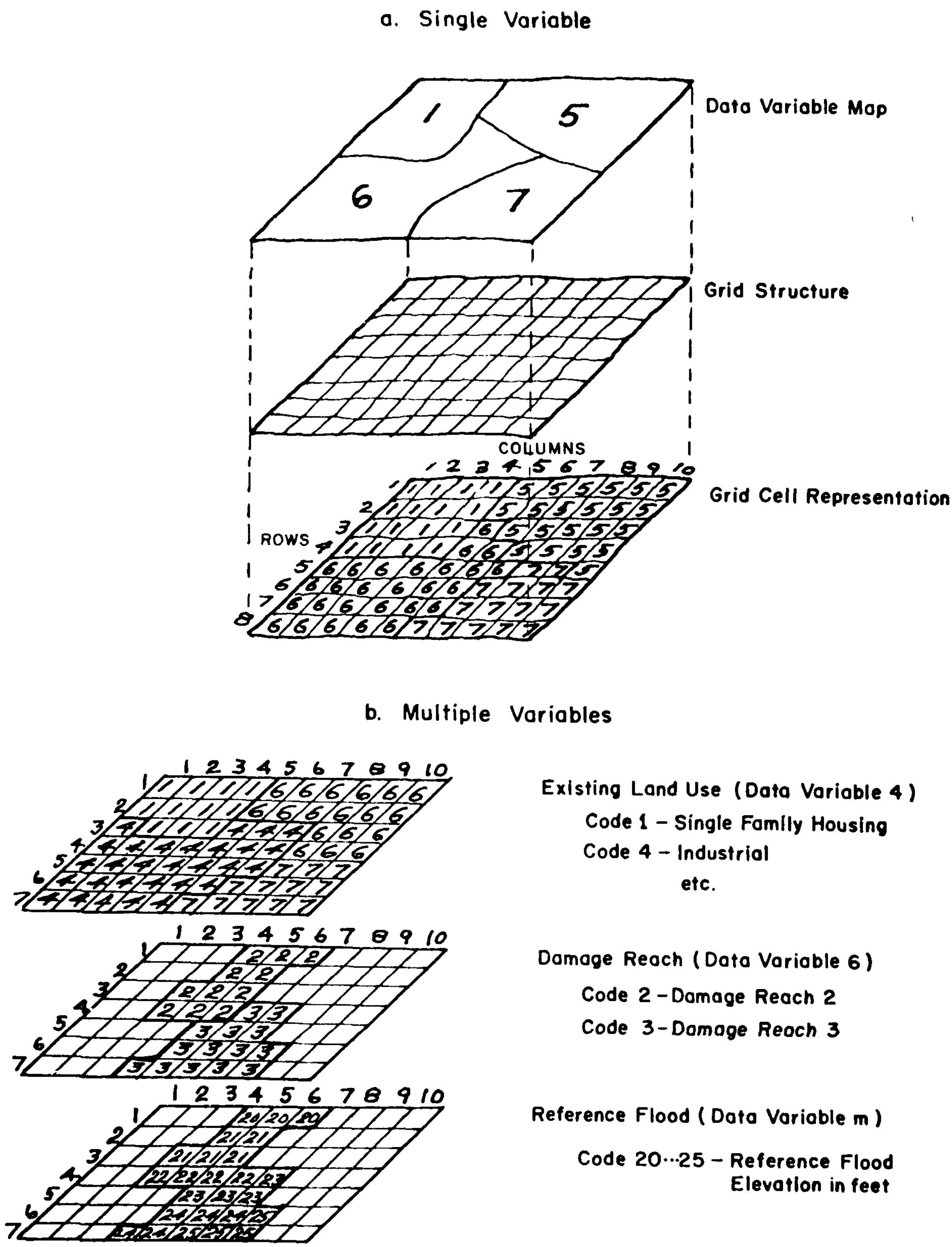


Figure 2.
GRID CELL
DATA BANK CONCEPTS

DAMAGE FUNCTIONS USING SPATIAL DATA APPROACH

Overview

The spatial data management technique for generating elevation-damage functions adapts traditional methods to the grid cell data bank concept. The methodology consists of constructing a unique elevation-damage relationship for each grid cell within the flood plain (based on topographic ground elevation, land use, and composite damage function assigned to the grid cell) and aggregating all of the grid cells assigned to a particular damage reach to each appropriate index location using a reference flood as the mechanism for adjusting for a sloping water surface profile (Hydrologic Engineering Center, 1975).

Damage Reaches

Damage reach boundaries are determined based on the traditional procedure that includes determining reaches with consistent parallel water surface profiles for the range of discharges which are significant to the calculation of expected annual damages while maintaining the economic detail desired for analysis. The damage reach boundaries are encoded and processed into the grid cell data bank with each cell within a reach assigned the reach identification value. The damage reach identification is used to aggregate grid cells to the appropriate damage reach index location.

Reference Flood

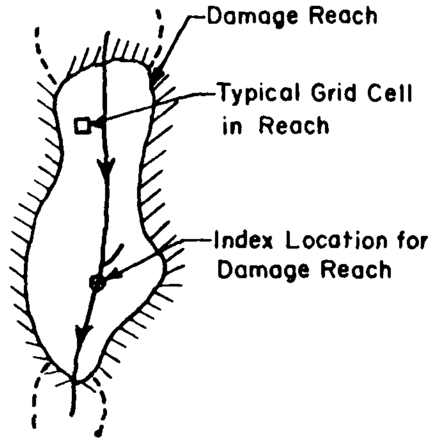
Since flood profiles result in different water surface elevations throughout a damage reach, a reference flood is used as a device to properly adjust the elevation for aggregation purposes, of each cell within the reach

with respect to the index location. Each cell is assigned a reference flood water surface elevation which is used with the reference flood elevation at the index location to adjust the composite damage function for proper aggregation of damages at the index location. A schematic of this process is shown in Figure 3, Damage Function Development (Hydrologic Engineering Center, 1975).

The reference flood placed in the data bank is a flood within the range which is critical for flood damage computation, usually a mid-range flood is selected to be a 25 to 50 year exceedance interval event. In studies that will examine flood plain management policies, it is useful to use an accurate 100 year profile as the reference flood. The reference flood elevations should be determined from detailed water surface profile analysis. If water surface profiles are not available, the slope of the flood profile through a damage reach may be curdely approximated by the slope of the thalweg (channel bottom) of the main stream or the slope of the adjacent flood plain itself.

Composite Damage Function

A composite damage function is defined as a stage-damage function for a unit area of a specific land use category that has significant damage potential. These functions may be developed by averaging the structural and related content values obtained from sampling a range of structure values and types within each land use category by use of field surveys, or by the review of tax records and interviews conducted with regional and local agencies, or other traditional field survey methods. The composite damage function may include direct and indirect damages that are associated with each particular



DATA REQUIRED

5	Grid representation of land use (exhaustive for study area).
321.6	Grid representation of topography (elevations).
325.0	Grid representation of reference flood (water surface elevation at reference flood) for each grid cell.
12A	Grid representation of Damage Reach Boundary.
A	Composite stage-damage functions for each significant land use.

INDEX LOCATION DAMAGE FUNCTION CONSTRUCTION

STEP 1, Develop Elevation - damage Function at Each Cell

a. Determine land use from grid file
b. Retrieve appropriate composite stage damage function
c. Determine grid elevation of cell from grid file
d. Tabulate elevation-damage for cell from above

STEP 2, Aggregate Cells to Index Location

a. Determine cell damage reach assignment
b. Determine index location reference flood elevation (X_1)
c. Determine cell reference flood elevation (X_2)
d. Adjust cell elevation-damage function by (X_2-X_1)
e. Aggregate cell adjusted elevation-damage function at index station
f. Repeat for all grid cells

DAMAGE FUNCTION DEVELOPMENT

Figure 3

land use category. Table 1, Composite Damage Function for Low Density Residential Land Use Category, illustrates an example of a composite stage-damage function of a land use category. A function is developed for each land use category of interest in the investigation.

Aggregate Damage Function

The flood damage associated with each grid cell is determined by matching the land use for each grid cell with the appropriate composite damage function (in effect placement of the function on the elevation assinged to the cell). The individual cell elevation-damage functions are then aggregated to the appropriate index location by use of the mechanism of the reference flood. A schematic of this procedure is shown in Figure 3, referred to previously. The computer program DAMCAL that performs the aggregation may also be used to develop the composite damage function. The following types of information are used in developing the composite stage-damage function for a specific land use category.

- stage vs % damage for structure
- stage vs % damage for contents
- value of structure
- value of contents (option available - % of structure value)
- indirect damage (option available - dollar amount or % structure and contents)
- development density (number of structures per grid cell)
- vacancy allowance (the proportion of land classified in the particular category that is in fact developed)

Table 1

EXAMPLE COMPOSITE DAMAGE FUNCTION

HIGH DENSITY RESIDENTIAL

DEPTH OF WATER	PER CENT DAMAGE STRUCTURE	PER CENT DAMAGE CONTENTS	AMOUNT OF DAMAGE PER GRID CELL IN THOUSAND DOLLARS
-2.00	0.00	0.00	0.00
-1.00	4.70	1.80	5.07
.10	13.30	13.60	17.28
1.00	17.70	46.40	32.80
2.00	20.70	64.50	41.91
3.00	24.00	76.40	49.15
4.00	27.00	84.50	54.79
5.00	31.00	88.20	59.86
6.00	34.00	92.70	64.25
7.00	38.30	93.60	68.63
8.00	42.30	95.50	73.06
9.00	48.70	95.50	79.11
10.00	57.70	95.50	87.62

DENSITY OF THE LAND USE UNITS PER GRID CELL = 4.00

BASE VALUE OF THE STRUCTURE = 30000.00

BASE VALUE OF THE CONTENTS = 11000.00

VACANCY FACTOR (PER CENT DEVELOPED) = 75.0

INDIRECT DAMAGES IS 5.00 PERCENT OF THE TOTAL

The data is prepared by land use category and DAMCAL accesses the grid data file and computes elevation-damage relations for all pertinent land use categories and damage reaches

Once the composite damage function has been developed for the land use pattern of interest, the function can be easily adjusted to reflect each specified flood plain management alternative measure and the corresponding performance criteria that are of interest in plan formulation. The capability to automatically adjust these functions is provided by DAMCAL.

Land Use

Land use concepts are a significant aspect of the spatial approach to damage appraisal. The care with which categories are chosen, and classification performed to a great degree control the accuracy of the results. Nomination of large numbers of categories (more than 20) can result in an apparent improvement in accuracy for existing development, but greatly complicate assessment of futures (its hard enough to forecast 3-5 categories, much less 20 or more). Also, averaging does have some virtues - today's flood plain development is one sample in time, it will likely change somewhat within existing buildings. Overemphasizing the detail of present use can lead one away from the central concept of all flood plain management actions - preventing damage in the future. Clearly a balance must be struck between adequate capturing of variation within and among use types, and prudence in use of investigation resources. While much is yet to be learned, it does appear that an upper practical bound in land use categories for damage analysis purposes is in the range of 15 to 20.

Example Results

Expected annual damage calculations require that the aggregate damage functions be merged with the rating curve and the flow exceedance frequency curve that have been derived by conventional or other means for the index location. In recent pilot studies for expanded flood plain information studies, the computer program HEC-1 (Hydrologic Engineering Center, 1975) was used to coordinate the data and perform the computations. The data transfer and coordination tasks were automated for that application. Other traditional damage calculation programs could be used equally as effectively.

Table 2, Summary Damage Evaluations (Davis, 1978) summarizes selected expected annual damage assessments for a range of watershed conditions and land use control policy sets for damage reaches within the Trail Creek watershed, a 12 $mi.^2$ tributary to the Oconee River in Athens, Georgia, selected to test the techniques.

The results are somewhat surprising and at first glance may be difficult to understand. An initial reaction might be that evaluation condition CODE IV should be similar to CODE I since the policy of no new development occurring at elevations below the 100-year event is in effect. The table shows a large increase in expected annual damages. This increase is because (1) damage does occur for new basement construction, (2) the 100-year flood for 1990 land use conditions is higher than the 100-year flood for existing land use conditions thereby increasing damage to existing development, and (3) damage is sustained by new development from events that exceed the 100-year event. Several other evaluations that include a number of alternative control and flood proofing policies are included to demonstrate the broad capability

TABLE 2

SUMMARY DAMAGE EVALUATIONS

(Expected Annual Damage in 1000's $)

	EVALUATION CONDITION		DAMAGE REACH			
CODE	LAND USE POLICY[1/]	HYDROLOGY	1	2	3	TOTAL
I	Existing	(1975) Existing	1.5	1.9	11.9	15.3
X	1990 with no development controls	1990	1033.3	350.0	32.7	1416.0
IV	1990 with new development at 1975 100-year flood level	1990	19.3	63.8	23.8	106.9
V	1990 w/new devel. @ 1975 100-year and flood proofed to ground floor	1990	16.8	18.9	4.7	40.4
VIII	1990 w/new devel. @ 1990 100-year and flood proofed to ground floor	1990	11.9	16.0	2.8	30.7

1/ The 1990 land use condition is a projection based on local agency judgement. In some instances, such as Damage Reach #3, 1990 urban type development has displaced several acres that are presently agricultural.

of the spatial data management technique as well as present some interesting evaluations of policies designed to manage flood losses. The capabilities of the spatial data management technique for evaluating a range of nonstructural flood plain management measures is described by (Webb and Burnham, 1976).

Significant Characteristics

Several significant characteristics of flood damage appraisals using spatial data management techniques are important to emphasize.

a) The approach emphasizes a land use focus in damage assessments.

b) It is technologically sensitive and responsive to policy analysis.

c) It is by nature highly computerized and amenable to automated analysis.

d) A high quality gridded data base is required to assure the fidelity of the results.

e) The overall technique and investigative environment in which it is operable encourages a geographic approach to flood plain management.

f) The focus is moved away from specific (and perhaps unique and important in some instances) structures as the basis for assessment.

UNIQUE STRUCTURE INVENTORY

The land use focus, while significantly advancing flood plain management ideals in most respects, can result in loss of important detail and thus credibility when attempting to make definitive estimates for existing flood plain development within which there may exist single, isolated unique structures. Such structures could be industrial complexes, specialty commercial enterprises, churches, historic buildings and the like.

To accommodate this need, a specific structure inventory computer program (STRUCTURE INVENTORY) was developed during the comprehensive pilot studies that had the following features

. Provides a computerized structure inventory capability,

. Adaptable as a complete or partial (supplement to) alternative to the spatial approach,

. Capable of systematically managing data on unique damage potential and value for structures,

. Compatible with spatial data files so that aggregation, policy analysis, and data file integration can be performed.

The basic concept of automating a structure inventory is not new in principle or practice. However, the careful construction of the data handling features, such that STRUCTURE INVENTORY files are compabible with spatial gridded data files and sensitive to policy analysis, is quite unique. In effect, the basic groundwork was laid for the subsequent integrated analysis using spatial and unique structure data that is described later.

Figure 4, Damage Survey Field Form, was designed to systematize the field data collection task for the structure inventory program and can serve as a vehicle to describe the specific features of the capability. Note that data are needed for the REACH, 1st FLOOR ELEV, REF FLOOD ELEV, and BASEMAP ROW and COLUMN all in upper right corner of the form. These are the same data used in the spatial approach and may be recorded directly upon the form, if available, or if the coordinates (row and column) are recorded, these data can be automatically retrieved from the grid cell data

STUDY ______ DATE ______ PREPARED BY ______	**DAMAGE SURVEY FIELD FORM** DRAFT 3/77 RPW HEC	REACH ______ BLDG I D ______ 1st FLOOR ELEV ______ REF FLOOD ELEV ______ RIVER MILE ______ BASEMAP ROW ______ COLUMN ______

ADDRESS ______

BLDG SIZE ______ STRUCTURE & MATERIAL TYPE ______

LAND USE CATEGORIES

LOCATION	DAMAGE TYPE	VALUE	DAMAGE FUNCTION
FIRST FLOOR	STRUCTURE (1FS)		
	CONTENTS (1FC)		
	OTHER (1FO)		
BASEMENT	STRUCTURE (BS)		
	CONTENTS (BC)		
	OTHER (BO)		
ABOVE FIRST FLOOR	STRUCTURE (AS)		
	CONTENTS (AC)		
	OTHER (AO)		

REMARKS ______

BUILDING TYPE FOR DAMAGE CALCULATION PURPOSES

1 FIRST FLOOR ONLY OR COMPOSITE
2 FIRST FLOOR AND BASEMENT
3 FIRST FLOOR AND FLOORS ABOVE
4 THE WORKS (BASEMENT, FIRST FLOOR, AND ABOVE)

FIRST CARD

REACH	BLDG I D		ROW	COLUMN	LAND USE	1ST FLOOR ELEV	REF FLOOD ELEV.	BUILDING TYPE	1FS DMGE FUNCTION
1 2 3 4	5 6 7 8	9	10 1 2 3	4 5 6 7	8 9 20 1 2	3 4 5 6 7 8 9	30 1 2 3 4 5 6	7 8	9 40
		1							

1FS VALUE	1FC DMGE FUNCTION	1FC VALUE	1FO DMGE FUNCTION	1FO VALUE	BS DMGE FUNCTION	BS VALUE	BLANK
41 2 3 4 5 6 7 8	9 50	1 2 3 4 5 6 7 8	9 60	1 2 3 4 5 6 7 8	9 70	1 2 3 4 5 6 7 8	9 80

SECOND CARD

REACH	BLDG I D		BC DMGE FUNCTION	BC VALUE	BO DMGE FUNCTION	BO VALUE	AS DMGE FUNCTION	AS VALUE	AC DMGE FUNCTION
1 2 3 4	5 6 7 8	9	10 1	2 3 4 5 6 7 8 9	20 1	2 3 4 5 6 7 8 9	30 1	2 3 4 5 6 7 8 9	40 41
		2							

AC VALUE	AO DMGE FUNCTION	AO VALUE	ADDRESS
42 3 4 5 6 7 8 9	50 1	2 3 4 5 6 7 8 9	60 1 2 3 4 5 6 7 8 9 70 1 2 3 4 5 6 7 8 9 80

SPR ---- 230 (Test)

Figure 4

bank. It is possible to specify a set of unique generalized damage functions for the basement, first floor, and subsequent floors if desired, and separate values for each if appropriate. The actual dollar estimates of damage by stage may be directly input if desired. Note also that a land use assignment may be made. This is so that aggregations may be performed and the results be compatible with the spatial approach.

The STRUCTURE INVENTORY program accepts data from the field coded forms and creates a structure file. Other options can then be exercised to aggregate data to index locations, group and count structures, and form aggregate damage functions for nonstructural alternatives such as selective flood proofing, evacuation, partial warning, etc. The file is created such that it may interface with the gridded file, should that prove advantageous.

INTEGRATED SPATIAL AND INVENTORY APPROACH

The observation that an extremely powerful data management approach would be created if the advantages of both the gridded spatial technique and structure inventory were capitalized upon led to the initiation of the development of an integrated analysis capability. The objectives of the integrated approach were defined as:

- Integrate data management and processing to exploit the respective strengths of each approach,
- Coordinate data needs between approaches so that businesslike field work could service both,
- Prepare computer code so that input and output products are

compatible between programs and both ultimately service the comprehensive processing programs that are subsequently used,

. Preserve, and to the extent possible, enhance the policy flexibility and sensitivity of the respective analyses.

The strategy to accomplish the integrated analysis is based upon preservation of the independence of the spatial and inventory processing programs so that they could be used independently when appropriate. A utility program is being developed that will form the processing interface between the two programs and the data base. This program will scan the data file of inventoried structures to identify the coordinates of cells containing specially catalogued structures, access the grid cell data bank and flag those cells identified so that processing by the spatial program DAMCAL can be adjusted to prevent double counting, and retrieve from the grid file such data as may be missing in the structure file, such as reference flood or ground elevation. The program would then, after aggregate function construction by each separate program, merge the results into a single aggregate file for subsequent analysis in a business-as-usual fashion by other analysis programs such as HEC-1, or by hand for that matter.

PROGRAM STATUS AND AVAILABILITY

Grid Cell Data Bank Creation

The paper presented earlier in this Symposium by Webb and Smith, "....Variables Are NOT Created Equal", describes the present attitude of Corps of Engineers practicioners on creation of data banks. A manual (Hydrologic Engineering Center, 1978) has recently been issued describing

guidelines for creating grid cell data banks and catalogues the computer software necessary to perform the task efficiently and lists where each program may be obtained.

DAMCAL - Spatial Processing Program for Damage Functions

This program was originally developed for the first Corps of Engineers pilot Expanded Scope Flood Plain Study in 1975, and has undergone steady refinement and improvement since then. It has been applied in several studies in the production mode. Final documentation and computer code clean up are nearing completion so that it will be available for public release in mid to late summer 1978.

STRUCTURE INVENTORY

This program was developed in late 1977 to service the Rowlett Creek study reported on in this symposium by Lovell and Smith. The program was successfully tested on a portion of the Rowlett Creek study area and additional testing and application is anticipated in the coming months. It is expected that the program will be prepared for public release late in 1978 or early in 1979. Informal copies of computer code and user documentation may be obtained from the Hydrologic Engineering Center.

Integrated Spatial and Inventory Analysis

Modifications to the basic spatial and inventory programs has been initiated. The utility program that will perform the interface and integration is presently in the active development category. It is expected that the integrated package will be available for applications in late 1978 and ready for public release in mid to late 1979.

SUMMARY AND CONCLUSIONS

Concepts and implementing computer programs have been developed that provide for damage appraisals using modern techniques of spatial data management. The applications to date confirm the soundness of the approach and suggest the methods promise to aide in continuing the important movement toward a geographic approach to flood plain management.

LITERATURE CITED

Davis, D.W., Comprehensive Flood Plain Studies Using Spatial Data Management Techniques. Journal of the American Water Resources Association, June 1978, pp. 587-604.

The Hydrologic Engineering Center, Expected Annual Damage Computations, June 1977.

The Hydrologic Engineering Center, Guide Manual for the Creation of Grid Cell Data Banks, June 1978.

The Hydrologic Engineering Center, Phase I Oconee Basin Pilot Study, Trail Creek Test, September 1975.

Webb, R.P., and Burnham, M.W., Spatial Data Analysis of Nonstructural Measures, Symposium on Inland Waterways for Navigation, Flood Control and Water Diversions, ASCE, August 1976.

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